

**VIBRATIONAL SPECTROSCOPIC STUDY OF FELDSPATHIC GLASSES IN SNC METEORITES.** E. Jagoutz<sup>1</sup> and A. Kubny<sup>1</sup>, <sup>1</sup>Max-Planck-Institut für Chemie, P.O. Box 3060, D-55020 Mainz, Germany (jagoutz@mpch-mainz.mpg.de, kubny@mpch-mainz.mpg.de).

**Introduction:** Feldspathic glasses in most SNC meteorites are optically isotropic. Previous authors have generally assumed that these phases, often called "maskelynite", formed by solid-state processes [1]. Since 1997 several reports have presented petrologic evidence that the "maskelynite" in some shocked chondritic and SNC meteorites is a dense glass quenched from shock-induced melts at high pressures [2-4]. Micro-Raman spectra of feldspathic glasses in the SNC meteorite ALH 84001 have been interpreted in terms of shock-induced melting of feldspar and subsequent quenching after relaxation of the peak shock pressure [5]. Further infrared and Raman spectroscopic studies are needed to confirm such an origin of the feldspathic glasses of SNC meteorites and to constrain their shock history. This study reports results of infrared and Raman spectroscopy on selected individual feldspathic glass grains of the SNC meteorites Shergotty (101 and 232), ALHA 84001, EETA 79001 (47 and 276), and Dar al Gani 476 and diaplectic feldspathic glasses of the Ries Crater, Germany. The feldspathic glasses of the SNC meteorites studied have the following compositions (data from Metbase): Shergotty (An 41 - 56, Ab 43 - 56, Or 1 - 3, K<sub>2</sub>O 0.4 %), ALHA 84001 (An 31, Ab 63, Or 6 %), EETA 79001 (An 55 - 60, Ab 39 - 44, Or 1 - 1.5 %), Dar al Gani 476 (An 52 - 72 %).

### Results and Discussion:

**Infrared spectra.** The micro-infrared transmission spectrometry is a nondestructive instrumental method for the detection and determination of dissolved and structural water in minerals. The transmission spectra of feldspathic glasses of the SNC meteorites mentioned above were collected from selected optically transparent grains and platelets 100 to 300  $\mu\text{m}$  in diameter. The transmission spectra show that absorption bands in the wavenumber regions of about 3600 and about 3400  $\text{cm}^{-1}$  which could be associated with structural and molecular water, can not be detected or are at the detection level. This indicates that the feldspathic glasses of the SNC meteorites are water-poor. The water content can be estimated to be below 100 ppm (< 0.01 wt %). The transmission spectrum of a laboratory-fused glass grain of Dar al Gani 476 displays quite the same features as those of the original glass grain without water absorption bands.

Mid-infrared transmission spectra in the range 1400 to 700  $\text{cm}^{-1}$  were also obtained by the KBr powder micropellet method. The transmission spectra exhibit the following main absorption bands (frequencies in

$\text{cm}^{-1}$ ): Shergotty 101: 1033 vs br, 794 w br; Shergotty 232: 1052 vs br, 796 w br; ALHA 84001: 1047 vs br, 795 w br; EETA 79001 - 47: 1075 vs br, 879 sh, 756 w br; EETA 79001 - 276: 1031 vs br, 761 w br; Dar al Gani 476: 1063 vs br, 879 s br, 753 vw br.

The spectra show in the 1400 to 700  $\text{cm}^{-1}$  wavenumber region a very strong broad band positioned at 1070 to 1030  $\text{cm}^{-1}$  and a weak broad band at 800 to 750  $\text{cm}^{-1}$ , which are typical for glasses. In the spectrum of feldspathic glass from EETA 79001 - 47, a shoulder flanking the most intense peak at approximately 880  $\text{cm}^{-1}$  can also be observed. The spectrum of the glass from Dar al Gani 476 exhibits two strong broad bands at 1060 to 1080  $\text{cm}^{-1}$  and 870 to 890  $\text{cm}^{-1}$  as well as a very weak band at 753  $\text{cm}^{-1}$ .

The high-frequency bands at about 1050  $\text{cm}^{-1}$  and the mid-frequency bands at about 760  $\text{cm}^{-1}$  have been associated with the Si - O stretching and the O - Si - O bending (or Si - O - Si stretching) modes of the SiO<sub>4</sub> tetrahedron and the tetrahedral linkages.

The transmission powder spectra of the glasses from SNC meteorites have great similarity to those of melt glasses of terrestrial feldspars, e.g., albite, which shows absorption bands at 1030 vs br, 783 - 700 w br, and 464  $\text{cm}^{-1}$  m [6, 7], anorthite [7], and oligoclase (An<sub>24</sub>) [8].

The spectrum of a laboratory-fused glass grain of Dar al Gani 476 has broad absorption peaks at 1075 to 1095  $\text{cm}^{-1}$  and 845 to 860  $\text{cm}^{-1}$ , which is quite similar to the spectra of the original glasses of Dar al Gani 476. The band at 1075 to 1095  $\text{cm}^{-1}$ , however, shifts slightly to higher frequencies compared to the position of the band in glasses of Dar al Gani 476 which appears at 1060 to 1080  $\text{cm}^{-1}$ . Also, the frequency band at 845 to 860  $\text{cm}^{-1}$  is shifted to lower frequencies compared to 870 to 890  $\text{cm}^{-1}$  observed for original glasses of Dar al Gani 476.

Because the structures of solid state glass and liquid state glass are likely to be different, the infrared absorption spectra of diaplectic glass should be distinguishable from the spectra of melt glass. To prove this assumption the powder transmission spectrum of diaplectic feldspathic glass (Or<sub>56</sub>, Ab<sub>44</sub>) in a granitic rock of shock stage II from the suevite breccia of Aufhausen, Ries Crater, Germany, and that of a laboratory-fused feldspathic glass of the same specimen were measured. The spectrum of the natural diaplectic glass shows absorption bands at ca. 1120 sh, 1043 vs br, 796 vw, 779 vw, 702 vw br, 630  $\text{cm}^{-1}$  vw br. The spectrum of the laboratory-fused glass of the same

specimen displays bands at ca. 1160 sh, 1044 vs br, 812 vw, 763 vw, 696  $\text{cm}^{-1}$  vw. The absence of sharp bands in both spectra indicates that the materials are in disordered state. However, the spectrum of the laboratory-fused glass exhibits a band shape of the Si-O antisymmetric mode, which is broadened in comparison to that of the natural diaplectic glass, but the band appears at the same 1044  $\text{cm}^{-1}$  position.

**Raman spectra.** The Raman spectra of the feldspathic glasses of the studied SNC meteorites were measured in the frequency range 250 to 1200  $\text{cm}^{-1}$ . The prominent features in the Raman spectra are broad bands in the ranges 1000 to 1040, 720 to 760, and 490 to 496  $\text{cm}^{-1}$ . The broadness of the bands and the lack of fine structure in the spectra result directly from the disordered state of the glassy material. The following band positions were determined:

Shergotty 101: 1016  $\text{cm}^{-1}$  vw br; Shergotty 232: 1040 w br, ca. 760 vw br, 495  $\text{cm}^{-1}$  w br; ALHA 84001: 1080 sh, 1002 m br, ca. 720 vw br, 496  $\text{cm}^{-1}$  s br; EETA 79001 - 47: 1087 sh, 1019 w br, ca. 744 vw br, 490  $\text{cm}^{-1}$  w br; EETA 79001 - 276: 1040 w br, ca. 750 vw br, 494  $\text{cm}^{-1}$  m br; Dar al Gani 476: 1007  $\text{cm}^{-1}$  vw br.

The high-frequency bands in the range 1000 to 1040  $\text{cm}^{-1}$  result primarily from the antisymmetric-stretching modes of O atoms  $\nu_{\text{as}}(\text{T-O-T})$ , T = Si, Al, and network forming cations in the three-dimensional aluminosilicate framework. The presence of shoulders in the high-frequency region at 1080  $\text{cm}^{-1}$  (ALHA 84001) and 1087  $\text{cm}^{-1}$  (EETA 79001 - 47) can be accounted for by lowering of the  $\text{SiO}_4$  tetrahedra site symmetries resulting from the presence of adjacent  $\text{AlO}_4$  tetrahedra.

Intermediate-frequency features appearing between 700 and 800  $\text{cm}^{-1}$  are common to the spectra of tetrahedral network glasses and are attributed to an intertetrahedral deformation mode involving significant cation motion.

The appearance of a vibrationally distinct symmetric stretching mode of O atoms  $\nu_{\text{s}}(\text{T-O-T})$ , T = Si, Al, in the range 490 to 496  $\text{cm}^{-1}$  indicates that relatively large domains of more or less homogeneous ring structure must exist in the glasses. The correlation between the frequencies 490 to 496  $\text{cm}^{-1}$  of  $\nu_{\text{s}}(\text{T-O-T})$  and ring size ( $\text{SiO}_4$  and  $\text{AlO}_4$  tetrahedra) in the three-dimensional network structures [9] indicates that the glasses are composed predominantly of five-membered rings or alternating four and six-membered rings. The absence of the low-frequency band in the range 380 to 510  $\text{cm}^{-1}$  in the Raman spectra of the feldspathic glasses of Shergotty 101 and Dar al Gani 476 reflects low concentrations of distinct ring structures in the glasses.

**Conclusions:** The water content of less than 100 ppm ( $< 0.01$  wt%) estimated from infrared transmission spectroscopy demonstrates that the feldspathic glasses of the studied SNC meteorites were probably made by shock-melting. Impact glasses usually have water contents below 500 ppm ( $< 0.05$  wt%).

The infrared powder transmission and Raman spectra of feldspathic glasses of the studied SNC meteorites show broad bands typical of thermal feldspathic glasses. The absence of sharp bands indicates that the materials are in amorphous state.

The infrared powder transmission spectra of the feldspathic glasses of Dar al Gani 476 and those of the laboratory-fused feldspathic glasses from the same specimen are quite similar suggesting that such SNC meteorite glasses achieved their final structural configuration from quenching of a melt.

By comparing the powder transmission spectra of diaplectic feldspathic glass of the Ries Crater and that of the laboratory-fused glass from the same specimen, a broadening of the band of the antisymmetric Si - O stretching mode is observed in the spectrum of the laboratory-fused glass. Apparently, the intimate structure of diaplectic feldspar glass retains some crystalline characteristics which are lost when the diaplectic glass is melted and subsequently quenched under atmospheric pressure.

#### References:

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